METHOD AND DEVICE FOR MONITORING BLIND SPOTS OF A MOTOR VEHICLE

The present invention relates to a method and a device for monitoring blind spots of a motor vehicle according to the definition of the species in Claim 1 or Claim 10.

A driver of a vehicle is able directly to examine the region around his vehicle through the vehicle's windows, and indirectly through the vehicle's rear view mirrors. In this context, the driver is able to examine through the vehicle's windows predominantly the region in front of the vehicle and at the sides of the vehicle, whereas the region behind the vehicle may be examined using the vehicle's inside rearview mirror, and the regions laterally behind the vehicle may be examined using one or more of the vehicle's outer rearview mirrors.

Because of the restricted field of view of the driver and the geometrical relationships in a vehicle, that is, for example, because of posts between the vehicle's windows that hinder vision, it is generally not possible for the driver of the vehicle to examine all the regions around a vehicle without turning around or turning the head. Directly behind and in front of the vehicle there are regions that the driver is not able to examine. Similarly, there are regions at the side of the vehicle that the driver is not able to examine without a considerable change in the field of vision by turning his head. These difficult-to-examine regions at the sides of the vehicle are designated as blind spot regions of the vehicle, this region varying depending on the size and sitting position

of the driver as well as with the kind and the setting of the outside mirrors.

From EP 1 026 522 A2, a system is known for monitoring a region at the side of a vehicle in a dynamic traffic environment. In this context, the system has an IR transmitting unit and an IR receiving unit which are situated at the side of the vehicle. These IR transmitting and receiving units define a lateral region that is to be monitored, an evaluating unit establishing whether an object is located in the monitoring region.
The presence of an object in the monitored region is notified to the driver via a suitable display unit. What is disadvantageous in the known system is that the driver has also pointed out to him objects which are meaningless for the guidance of his vehicle.

The present invention is therefore based on the object of creating a method and a device for monitoring blind spots of a motor vehicle, the driver only receiving a warning if the object detected in the blind spot has a meaning with respect to the guidance of the vehicle.

The object is attained by the features of the method according to Claim 1 and those of the device according to Claim 9. Advantageous embodiments of the present invention are the subject matter of the dependent claims.

The method, according to the present invention, for monitoring the blind spot at the side of a motor vehicle, that activates a warning function for giving off a warning to the driver if an object is located in a predefined warning region, has the following steps:
a) determining the relative speed v_{rel} between object and motor vehicle, determining the travel direction of the object relative to the motor vehicle and determining the position of

the object relative to the motor vehicle within a predefined sensor region,

b) giving out a warning to the driver if the travel direction of the object corresponds to that of the motor vehicle, the relative speed v_{rel} between the object and the vehicle lies within a predetermined range, defined by a lower range boundary v_u and an upper range boundary v_o, the predetermined range of the relative speed including zero, and the position of the object (F2) lying within the warning range.

In this context, the relative speed is referred to the motor vehicle, in other words, if the relative speed is greater than zero, the object moves faster than the vehicle, and if the relative speed is less than zero, the object is slower than the vehicle. Objects may be, for example, pedestrians, vehicles, bicycles, motorcycles, trucks and buses. Objekte sind beispielsweise Fußgänger, Fahrzeuge, Fahrräder, Motorräder, Lastkraftwagen und Busse. Furthermore, the travel direction of the object relative to the motor vehicle is defined by the direction of the roadway on which the object is moving relative to the vehicle. In other words, with respect to the motor vehicle, an object is able to have only one of two travel directions, either it moves in the same travel direction as the vehicle or it moves in the opposite travel direction. In the latter case, then, two-way traffic is involved. As a result, an object that has the relative speed of zero with respect to the vehicle, and changes from an outer lane to a lane adjacent to the vehicle, has the same travel direction as the vehicle, although, with respect to the relative speed, it moves in a perpendicular direction towards the vehicle. Furthermore, the sensor range is predefined by the range of the sensor at which it detects objects, and the warning range is the range within which a warning is given off

to the driver, that is, the blind spot region. In this context, the warning range is a part of the sensor range.

Preferably, a warning is also generated at relative speeds greater than the positive upper range boundary v_o, i.e. in this preferred specific embodiment a warning is generated in response to all positive relative speeds, if the additional, above-named conditions are satisfied.

In particular, the predetermined range is defined by the interval of the relative speeds of -30 km/h to +100 km/h, preferably -15 km/h to +50 km/h, and especially 5 km/h to +30 km/h.

In an additional preferred specific embodiment, the range boundaries are a function of the speed of the motor vehicle, in other words, at a low speed of the vehicle, the range boundaries are lowered, whereas at a high speed, the range boundaries are shifted to higher relative speeds.

The warning function is preferably independent of the direction of entry of the object into the blind spot, and the direction of exit of the object from the blind spot. Furthermore, the warning function is independent of the background of the object that enters the blind spot, and independent of standing objects, of their alignment and their background.

In one additional preferred specific embodiment driving situations are classified, each classified driving situation including the information as to whether the warning function is activated or not, when an object enters the blind spot region. The method furthermore has the following steps: determining the current driving situation of motor vehicle and object, ascertaining that classified driving situation which corresponds to the current driving situation, and activating

the warning function corresponding to the information of the ascertained classified driving situation.

Preferably, the classification takes into account two additional lanes laterally to the lane of the motor vehicle. This measure is usually sufficient.

In particular, the evaluation of whether a warning function is triggered in response to the entry of an object into a blind spot or warning range of the motor vehicle, is carried out at both sides of the vehicle, in other words, both sides of the motor vehicle are monitored.

A device according to the present invention for carrying out the method explained above includes a sensor device for monitoring a blind spot, the sensor device determining the direction of motion of an object relative to the motor vehicle, the relative speed between the object and the motor vehicle, as well as the position of the object relative to the vehicle, a control unit for valuing the data ascertained, and a warning device for giving out a warning signal to the driver of the motor vehicle as a function of the valuing of the data. The position of the detected object relative to the vehicle is preferably determined by measuring the radial distance from the vehicle and measuring the angle at which the object is approaching.

In particular, the control device includes a memory for storing classified driving conditions and a comparator for comparing a current driving condition ascertained by the control unit from the data of the sensor device to the classified driving conditions.

The sensor device may be situated in a side mirror, an outer mirror, the rear bumper or a rear light of the motor vehicle.

A preferred embodiment of the present invention is explained below on the basis of the schematic drawings. The figures in the drawings show:

Fig. 1	a definition of the blind spot of a motor vehicle,
Figs. 2a - 2c	warning situations in response to selected driving situation,
Figs. 3a – 3c	situations without activation of the warning function,
Figs. 4a – 4c	a schematic representation of the preferred speed range,
Figs. 5a — 5d	possible entry directions and exit directions into a blind spot for vehicles in the same driving direction and for two-way traffic,
Figs. 6a – 6c	examples of classified driving situations having triggering of a warning signal, and
Figs. 7a – 7c	examples of classified driving situations without triggering of a warning signal.

Figure 1 shows a schematic representation of the so-called blind spots on each side of a motor vehicle. What is shown is a motor vehicle F1 which is traveling from right to left in the drawing, in the middle lane S2 of a roadway FB having three lanes S1, S2, S3. Both on the driver's side and on the passenger's side, in each case a rectangular region W1, W2 is shown, having edges a, b which define, for example, a rectangle of ca. 5 m x 5 m. These approximate regions W1, W2 are defined below as blind spot regions or warning regions, which are not able to be examined by the driver in the outside mirrors. The regions depend on the size and the sitting

position of the driver, as well as on the type and the setting of the outside mirrors. as well as on the construction of the vehicle itself. Furthermore, the size of the blind spot regions is a function of the driving situation, such as of the speed.

In the following Figures 2a-c, 3a-c, 5a-d, 6a-c, 7a-c and 8a-c, that vehicle into whose driver-side blind spot an object is entering, is designated as vehicle F7, and the object is specified by an additional vehicle F2, which is denoted as the object vehicle. The direction of motion of vehicle F1, whose blind spot is being considered, is from right to left in the plane of the drawings.

Figure 2a shows a passing procedure, in which two vehicles F1 and F2 have the same travel direction, and vehicle F1 is being slowly passed by faster object vehicle F2. Because of the penetration of object vehicle F2 into the driver's side blind spot region W1 of vehicle F1, a warning is triggered.

Figure 2b shows a situation comparable to that in Figure 2a, in which object vehicle F2, located in blind spot region W1 of vehicle F1, has the same speed as vehicle F1. A warning to the driver of vehicle F1 takes place.

Figure 2c shows a situation in which object vehicle F2 slowly falls back compared to vehicle F1, which is shown by the arrow directed rearward, and wanders through the blind spot of vehicle F1. A warning to the driver of vehicle F1 takes place. Travel direction of the two vehicles F1, F2 is identical here too.

Additional situations, such as the ones shown in Figures 3a to 3c, in which a warning function is triggered by the penetration of an object into a blind spot of a vehicle, may

be defined both for the driver's side and, analogously, for the passenger's side.

Figure 3a shows a situation in which object vehicle F2 enters the driver's side blind spot W1 of vehicle F1 as two—way traffic. In principle, in the case of two-way traffic no warning is given.

Figure 3b shows the passing of vehicle F1 of standing vehicle F2. Here, too, there is no warning in response to an entry of a standing vehicle into the blind spot region of another vehicle.

Finally, Figure 3c shows a situation in which both vehicles move in the same travel direction, and object vehicle F2 drops back rapidly with respect to vehicle F1 that is moving in the same direction, which is shown by the bigger directional arrow shown pointing to the right in the drawing. In other words, object vehicle F2 runs through blind spot region W1 of vehicle F1 from front to back, and the situation may be described as a passing procedure of vehicle F1. No warning takes place in this situation.

Furthermore, no warning takes place if the blind spot region of a vehicle is empty independently of the background (not shown).

Figure 4 shows in an illustrated representation the ranges of relative speeds at which, in response to entry of an object into the blind spot region of a vehicle, a warning takes place or not. In this context, relative speed v_{rel} is referred to the vehicle, so as to arrive at a correct sign definition. In the case of relative speeds lower than a lower boundary v_u between the vehicle and an object, no warning is triggered, in the case of relative speeds within a range between the lower boundary v_u and an upper boundary v_o, this range including

relative speed zero, a warning is triggered, and in the case of relative speeds greater than upper boundary v_o, the triggering of a warning is optional. The range boundaries named may be functions of the own speed of the vehicle.

Figures 5a-5d show possible entry and exit directions in a blind spot of a vehicle for vehicles going in the same travel direction and for two-way traffic. The concepts used here with respect to the possible entry and exit direction, „right", "left", "front" and "rear" relate to the direction of motion of object vehicle F2.

Figure 5a shows schematically the 6 essential entry directions, represented by arrows 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6, in which vehicle F2 may enter the driver's side blind spot region W1 of vehicle F1. Also shown are three lanes S1, S2, S3 of a roadway FB. The arrows have the following meaning:

1.1 Entry direction at an angle left forward by change of vehicle F2 from lane S1 to lane S2 (relative speed greater than zero),
1.2 Entry direction forward by vehicle F2 remaining in lane S2 (relative speed greater than zero),
1.3 Entry direction at an angle right forward by change of vehicle F2 from lane S3 to lane S2 (relative speed greater than zero),
1.4 Entry direction to the right by change of vehicle F2 from lane S3 to lane S2 (relative speed equal to zero),
1.5 Entry direction at an angle right rearward by change of vehicle F2 from lane S3 to lane S2 (relative speed less than zero), and
1.6 Entry direction rearward by vehicle F2 remaining in lane S2 (relative speed less than zero),

Fig. Figure 5b shows schematically the 8 essential exit directions, represented by arrows 2.1, 2.2, 2.3, 2.4, 2.5 and

2.8, in which vehicle F2 may exit the driver's side blind spot region W1 of vehicle F1. The arrows have the following meaning:

2.1 Exit direction at an angle right rearward by change of vehicle F2 from lane S2 to lane S1 (relative speed less than zero),

2.2 Exit direction rearward by vehicle F2 remaining in lane S2 (relative speed less than zero),

2.3 Exit direction at an angle right rearward by change of vehicle F2 from lane S2 to lane S3 (relative speed less than zero),

2.4 Exit direction at an angle left by change of vehicle F2 from lane S2 to lane S3 (relative speed equal to zero),

2.5 Exit direction at an angle left forward by change of vehicle F2 from lane S3 to lane S2 (relative speed greater than zero), and

2.6 Exit direction forward by vehicle F2 remaining in lane S2 (relative speed greater than zero).

Figure 5b shows schematically the 2 essential entry directions, represented by arrows 3.1 and 3.2, in which vehicle F2 may enter the driver's side blind spot region W1 of vehicle F1 as two-way traffic. The arrows have the following meaning:

3.1 Entry direction at an angle left forward by change of vehicle F2, that is traveling in the opposite direction to the traffic, from lane S3 to lane S2, and

3.2 Entry direction forward by vehicle F2 remaining in lane S2.

Figure 5d shows schematically the 3 essential exit directions, represented by arrows 4.1, 4.2 and 4.3, in which vehicle F2 may exit the driver's side blind spot region W1 of vehicle F1. The arrows have the following meaning:

4.1 Exit direction at an angle left forward by change of vehicle F2, that is traveling in the opposite direction to the traffic, from lane S2 to lane S1,

4.2 Exit direction forward by vehicle F2, that is traveling in the opposite direction to the traffic, remaining in lane S2, and

4.3 Exit direction at an angle left forward by change of vehicle F2, that is traveling in the opposite direction to the traffic, from lane S2 to lane S3.

The above-named possible entry and exit directions into [and from] a blind spot of a vehicle for vehicles going in the same travel direction and for two-way traffic 1.1-1.6, 2.1-2.6, 3.1-3.2 and 4.1-4.3 are used to define the columns of a matrix that describes classified blind spot situations of the driver's side. The rows of the matrix are defined by background objects, such as "no objects", "moving objects", which are subdivided into "passing", "same speed", "dropping back" and "two-way traffic"; and "static objects", such as "pilons", "delineators", "trees", "traffic jam", "guardrail" and "tunnel wall". For every possible classified blind spot situation of the matrix it is stated whether a warning is to be given out in response to the occurrence of the situation or not.

Figures 6a-6c show three examples of a plurality of possible classified driving situations that have triggering of a warning signal which, in parameterized form, are components of the matrix explained above.

Figure 6a shows vehicle F1 moving in lane S1, along with object vehicle F2 traveling behind it, which changes in direction 1.1 to lane S2, and thereby arrives in blind spot region W1 of vehicle F1. Since the travel directions of the vehicles are identical, the relative speed is greater than

zero (and is within the predefined range) and the position of the object lies within the warning range, a warning is triggered. The object vehicle leaves again the blind spot region of vehicle F1 in direction 2.6.

Figure 6b shows vehicle F1 moving in lane S1. In lane S2 parallel to it, object vehicle F2 approaches from behind in direction 1.2, and enters blind spot region W1 of vehicle F7. Since the travel directions of the vehicles are identical, the relative speed is greater than zero (and is within the predefined range) and the position of the object lies within the warning range, a warning is triggered. The object vehicle leaves again the blind spot region of vehicle F1 in direction 2.6.

Figure 6c shows vehicle F1 moving in lane S1. Because of a change of object vehicle F2 in direction 1.3 to lane S3, it arrives in blind spot region W1 of vehicle F1. Since the travel directions of the vehicles are identical, the relative speed is greater than zero (and is within the predefined range) and the position of the object lies within the warning range, a warning is triggered. The object vehicle leaves again the blind spot region of vehicle F1 in direction 2.6.

Figures 7a – 7c show three examples of a plurality of possible classified driving situations without the triggering of a warning signal.

Figure 7a shows vehicle F1 having blind spot region W1, which is moving in lane S1 in predefined travel direction (i.e. in the plane of the drawing, from right to left). In lane S2, object vehicle F2 moves in opposite travel direction, in direction 3.2, and enters blind spot region W1 of vehicle F1. No warning is triggered. The object vehicle leaves the blind spot region again in direction 4.1, i.e. it changes lanes to lane S1. An additional vehicle F3 moves in lane S3 in the

opposite travel direction to vehicle F1. This vehicle is insignificant for the triggering of a warning, since it does not enter blind spot region W1.

Figure 7b shows vehicle F1 having blind spot region W1, which is moving in lane S1 in predefined travel direction (i.e. in the plane of the drawing, from right to left). In lane S2, object vehicle F2 moves in opposite travel direction, in direction 3.2, and enters blind spot region W1 of vehicle F1. No warning is triggered. The object vehicle leaves the blind spot region again in direction 4.2, i.e. it remains in lane S2. An additional vehicle F3 moves in lane S3 in the opposite travel direction to vehicle F1. This vehicle is insignificant for the triggering of a warning, since it does not enter blind spot region W1.

Finally, Figure 7c shows vehicle F1 having blind spot region W1, which is moving in lane S1 in a predefined travel direction (i.e. in the plane of the drawing, from right to left). In lane S2, object vehicle F2 moves in opposite travel direction, in direction 3.2, and enters blind spot region W1 of vehicle F1. No warning is triggered. The object vehicle leaves the blind spot region again in direction 4.1, i.e. it changes to lane S1. In lane S3 there is a traffic jam having vehicles F3, or there are parking vehicles. These vehicles F3 are insignificant for the triggering of a warning, since they are standing, and, as a result, are treated as background.

List of Reference Symbols:

F1	vehicle
F2	vehicle
F3	vehicle
FB	Roadway
W1	blind spot driver's side
W2	blind spot passenger's side
S1	lane
$2	lane
S3	lane
a	edge length
b	edge length
1.1 - 1.6	entry directions
2.1 — 2.6	exit directions
3.1 — 3.2	entry directions
4.1 — 4.3	exit directions
v_{rel}	relative speed
v_o	upper boundary
v_u	lower boundary